

Volume II: Hazard Annex

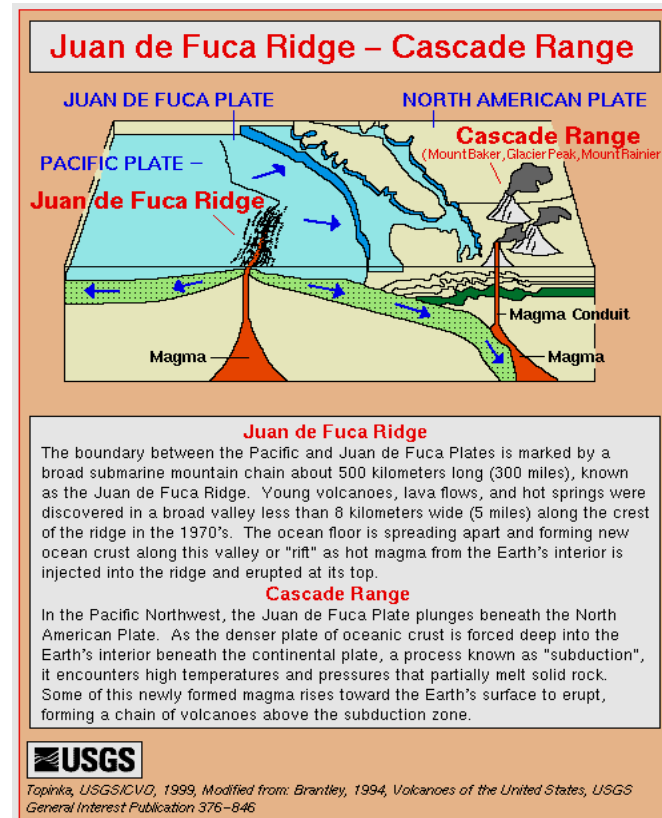
Volcanic Eruption

Causes and Characteristics of Volcanic Eruption

Marion County and the Pacific Northwest lie within the “ring of fire,” an area of very active volcanic activity surrounding the Pacific Basin (see figure 5 for volcano location on the west coast). Volcanic eruptions occur regularly along the ring of fire, in part because of the movement of the Earth’s tectonic plates. The Earth’s outermost shell, the lithosphere, is broken into a series of slabs known as tectonic plates. These plates are rigid, but they float on a hotter, softer layer in the Earth’s mantle. As the plates move about on the layer beneath them, they spread apart, collide, or slide past each other. Volcanoes occur most frequently at the boundaries of these plates and volcanic eruptions occur when the hotter, molten materials, or magma, rise to the surface. In Oregon, volcanic activity can be found along the Cascade Range which was formed by the Juan de Fuca plate sinking beneath the North American plate as shown in Figure 1.¹⁸⁸

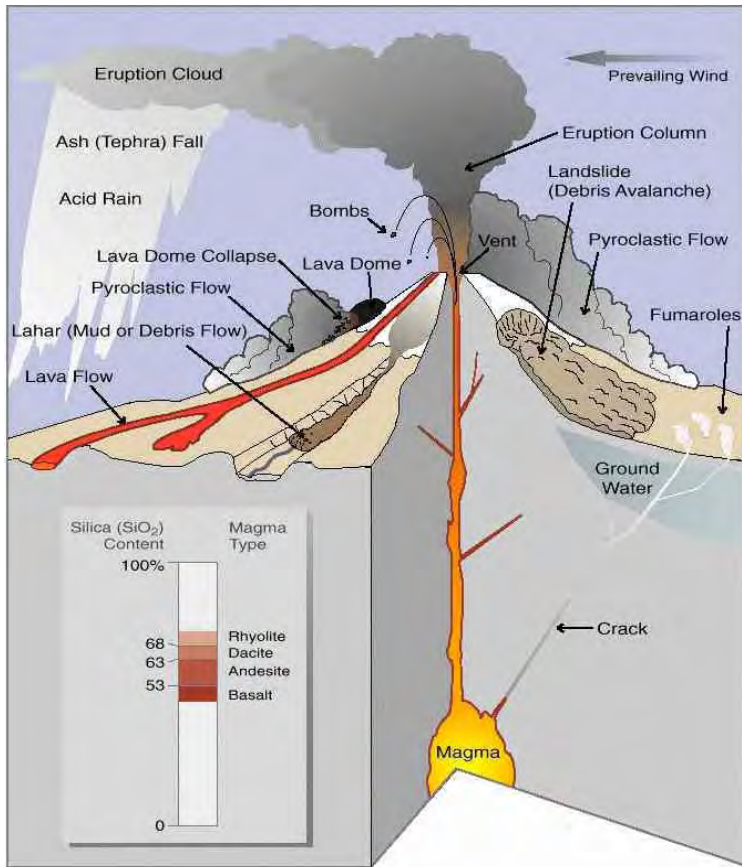
¹⁸⁸ Oregon State Natural Hazard Mitigation Plan. 2009.” Volcanic Hazards Chapter,” http://aaaweb1.uoregon.edu/opdr/sites/aaaweb1.uoregon.edu/opdr/files/OR-SNHMP_volcanic_chapter_2009_0.pdf, accessed February 12, 2010

Figure 1 Juan de Fuca Ridge



The primary threat to lives and property from active volcanoes is from violent eruptions that unleash tremendous blast forces, generate mud and debris flows, and produce flying debris and ash clouds. The immediate danger area in a volcanic eruption generally lies within a 20-mile radius of the blast site. Mount Jefferson is located in the southeastern corner of Marion County, increasing the risk to county residents. There are also a number of active volcanoes within the 100-mile danger areas that pose a threat to county residents and property. The threat they pose is associated primarily with ash fall. The following section outlines the specific hazards posed by volcanoes and are depicted in figure 2 below.

Figure 2 Schematic drawing of various volcanic hazards



Source: Fact Sheet 002-97, Meyers, USGS

Ash fall

One of the most serious hazards from an eruption is the rock (*bombs*) and dust-sized ash particles - called *tephra* - blown into the air. The dust-sized ash particles can travel enormous distances and are a serious by-product of volcanic eruptions. Within a few miles of the vent, the main tephra hazards to man-made structures and humans include high temperatures, being buried, and being hit by falling fragments. Within ten to twelve miles, hot tephra may set fire to forests and flammable structures.

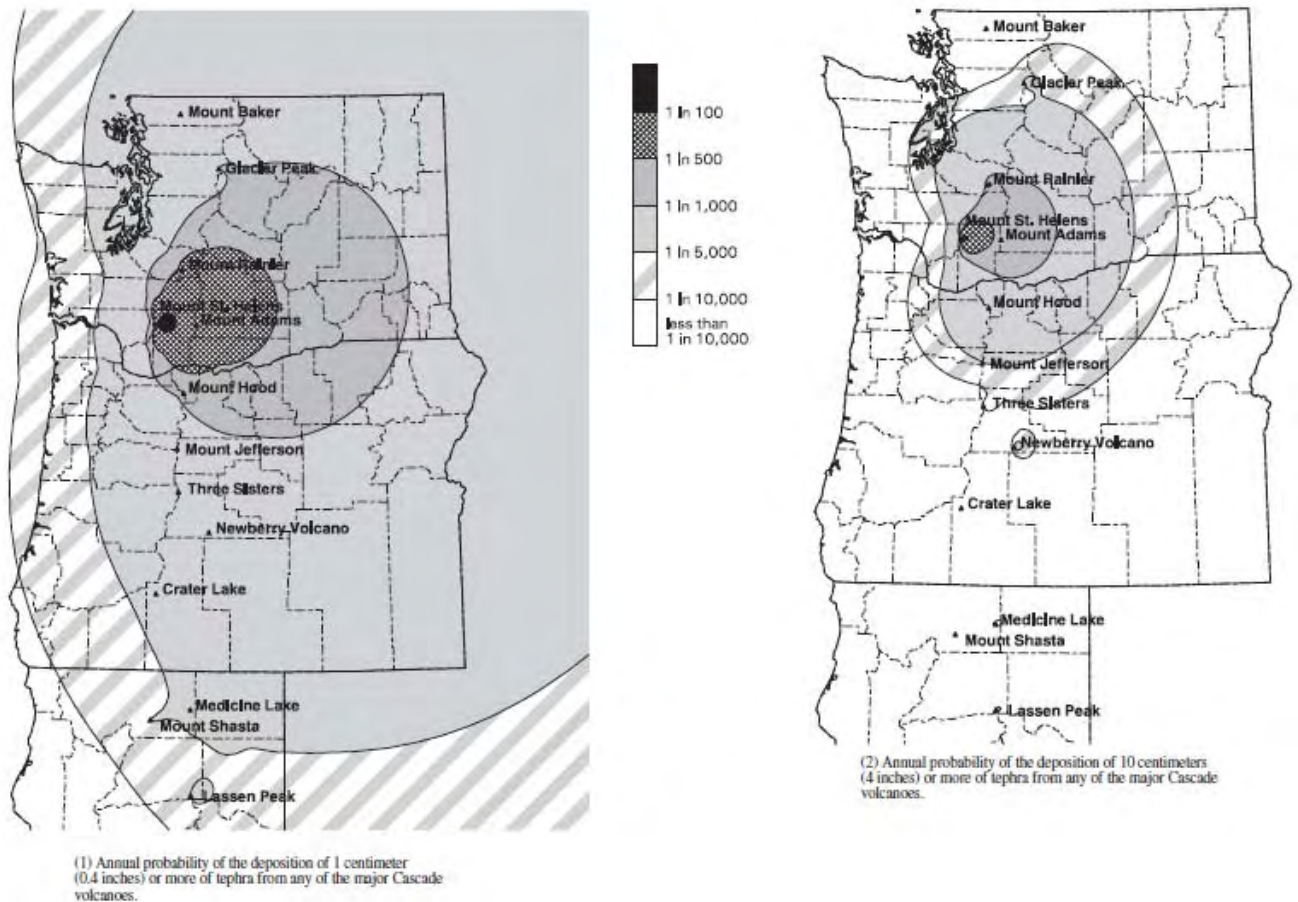
During an eruption that emits ash, the ash fall deposition is controlled by the prevailing wind direction.¹⁸⁹ The predominant wind pattern over the Cascades is from the west, and previous eruptions seen in the geologic record have resulted in most ash fall drifting to the east of the volcanoes.¹⁹⁰ The potential and geographical extent of volcanic ash fall in the Pacific

¹⁸⁹ Oregon State Natural Hazard Mitigation Plan. 2009. "Volcanic Hazards Chapter," http://aaaweb1.uoregon.edu/opdr/sites/aaaweb1.uoregon.edu/opdr/files/OR-SNHMP_volcanic_chapter_2009_0.pdf, accessed February 12, 2010

¹⁹⁰ Oregon State Natural Hazard Mitigation Plan. 2009. "Volcanic Hazards Chapter," http://aaaweb1.uoregon.edu/opdr/sites/aaaweb1.uoregon.edu/opdr/files/OR-SNHMP_volcanic_chapter_2009_0.pdf, accessed February 12, 2010

Northwest from an eruption on Mt. St. Helens is depicted in Figure 3 below.¹⁹¹

Figure 3 Regional Tephra-fall Maps



Source: USGS "Volcano Hazards in the Mount Jefferson Region, Oregon"

Earthquakes

Earthquakes can trigger volcanic eruptions or they can cause them. An earthquake produced by stress changes in solid rock from injection or withdrawal of magma (molten rock) is called a volcano-tectonic earthquake. The other categories of volcanic earthquakes, called longperiod earthquakes, are produced by the injection of magma into surrounding rock. Volcanic earthquakes tend to be mostly small and not a problem for areas tens of miles from the volcano.

Lava flows

Lava flows are streams of molten rock that erupt relatively non-explosively from a volcano and move downslope, causing extensive damage or total destruction by burning, crushing, or burying everything in their paths.

¹⁹¹ Oregon State Natural Hazard Mitigation Plan. 2009." Volcanic Hazards Chapter," http://aaaweb1.uoregon.edu/opdr/sites/aaaweb1.uoregon.edu.opdr/files/OR-SNHMP_volcanic_chapter_2009_0.pdf, accessed February 12, 2010

Secondary effects can include forest fires, flooding, and permanent reconfiguration of stream channels.¹⁹² The most likely instance of a lava flow in Marion County would occur near Mount Jefferson.

Pyroclastic flows and surges

Pyroclastic flows are avalanches of rock and gas at temperatures of 600 to 1500 degrees Fahrenheit. They typically sweep down the flanks of volcanoes at speeds of up to 150 miles per hour. Pyroclastic surges are a more dilute mixture of gas and rock. They can move even more rapidly than a pyroclastic flow and are more mobile. Both generally follow valleys, but surges sometimes have enough momentum to overtop hills or ridges in their paths. Because of their high speed, pyroclastic flows and surges are difficult or impossible to escape. If, it is expected that they will occur, evacuation orders should be issued as soon as possible for the hazardous areas. Objects and structures in the path of a pyroclastic flow are generally destroyed or swept away by the impact of debris or by accompanying hurricane-force winds. Wood and other combustible materials are commonly burned. People and animals may also be burned or killed by inhaling hot ash and gases. The deposit that results from pyroclastic flows is a combination of rock bombs and ash and is termed *ignimbrite*. These deposits may accumulate to hundreds of feet thick and can harden to resistant rock.¹⁹³ Residents in the southeastern corner of Marion County have a potential risk if these events occur at Mount Jefferson.

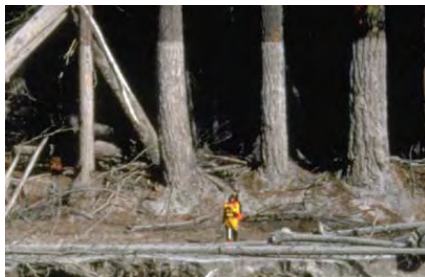
Lahars and debris flows

A lahar consists of a mixture of water and rock fragments that flow down the slope of a volcano, usually along a stream channel. A lahar can be generated by volcanic activity (for example, melting snow or glacier), prolonged rain, or other weather conditions resulting in rapid snow melt. When moving, a lahar resembles a mass of wet concrete carrying rocks and boulders. Lahars vary in size and speed. Large lahars may be hundreds of meters wide, tens of meters deep, and move faster than a person can run. The Cascade Mountains and nearby floodplains contain abundant evidence of lahar activity and destruction. Past lahars at Mount Hood completely buried valley floors in the Sandy, Hood, and White River drainages. Figure 4 illustrates the aftermath of a lahar.

¹⁹² Oregon State Natural Hazard Mitigation Plan. 2009. " Volcanic Hazards Chapter," http://aaaweb1.uoregon.edu/opdr/sites/aaaweb1.uoregon.edu.opdr/files/OR-SNHMP_volcanic_chapter_2009_0.pdf, accessed February 12, 2010

¹⁹³ Oregon State Natural Hazard Mitigation Plan. 2009. " Volcanic Hazards Chapter," http://aaaweb1.uoregon.edu/opdr/sites/aaaweb1.uoregon.edu.opdr/files/OR-SNHMP_volcanic_chapter_2009_0.pdf, accessed February 12, 2010

Figure 4 Lahar Aftermath



Source: DOGAMI. 2008. Oregon Geology Fact Sheet: Landslide Hazards in Oregon. <http://www.oregongeology.org/sub/publications/landslide-factsheet.pdf>, accessed February 11, 2010

Debris flows are sudden and very rapid movements of rock and soil downhill; they are often called mudslides. They can be triggered by a variety of phenomena, including weather conditions, very steep slopes, and earthquakes. Debris flows can travel miles and attain speeds as high as 100 miles per hour. Structures and objects in their path (e.g., dams, bridges) will sometimes be incorporated into the flow. They often contain enough water to transform into lahars. Debris flows are common throughout the steep volcanoes of the Cascade Range.

The major hazard to human life from lahars and debris flows is from burial and impact by boulders and other debris. Buildings, dams, bridges, and other property in the path of a lahar can be buried, smashed, or carried away. Flooding can occur behind temporary dams created by logjams or other debris in streams.

Lahars and debris flows can result in the disruption of utility and transportation systems. Municipalities, industries, and individuals who take their water from streams affected by lahars may have water quality and quantity issues. Endangered species could be adversely affected by changes in streams, including the deposition of debris in streambeds and floodplains. For example, salmonids trying to spawn could find it impossible to swim upstream.

Both debris flows and lahars can occur for many years after an eruptive episode at a volcano.

Landslides (debris avalanches)

Because the volcanoes that form the Cascade Mountains are composed of layers of weak fragmented rock and lava they are prone to gravity driven failure such as landslides. Landslides range in size from small to massive summit or flank failures. They may be triggered by erosion that oversteepens slopes or during times of excessive rainfall or snowmelt. Speeds of movement range from slow creep to more catastrophic failure. If enough water is incorporated into the material the failure will become a lahar. Primary hazards are to roads, bridges, dams, and buildings that might be constructed on the landslide or be damaged by the movement.

History of Volcanic Eruption in Marion County

There are five active volcanoes that could potentially impact Marion County. These include: Mount Jefferson, Three Sisters and Broken Top, Mount Hood, Mount St. Helens, and Mount Rainier (see Figure 5 below). However, only one of these volcanoes, Mount St. Helens, has impacted Marion County within the past 30 years. The closest volcano to Marion County, Mount Jefferson, has the potential to impact Marion County directly, but it has not been active for at least the past 15,000 years.

Figure 5 Volcanoes of the Western US



Source: USGS. <http://www.volcano.si.edu/reports/usgs/maps.cfm#usa>, accessed February 11, 2010

Mount St. Helens

Mount St. Helens, located in southwestern Washington about 70 miles northeast of Marion County, is fifty thousand years old. Over the past 521

years, it has produced four major explosive eruptions and dozens of smaller eruptions. On May 18th, 1980, Mount St. Helens “exploded violently after two months of intense earthquake activity and intermittent, relatively weak eruptions, causing the worst volcanic disaster in the recorded history of the United States.”¹⁹⁴

Damage to the built environment within the immediate hazard vicinity in Washington included twenty-seven bridges, about two hundred homes, more than 185 miles of highways and roads, and fifteen miles of railways. Ash from the eruption column and cloud spread across the United States in three days and circled around the Earth in fifteen days. Detectable amounts of ash were noted in an area covering 22,000 square miles. In Marion County, volcanic ash affected air filters on the RFPD No.1’s equipment.¹⁹⁵ No Oregon roads were closed, although fallout of volcanic ash restricted visibility and produced slippery roads and ash-clogged windshields.¹⁹⁶

Debris flows from the eruption quickly filled the Toutle and Cowlitz Rivers and ultimately flowed into the Columbia River at Longview, Washington. The debris blocked the main shipping channel in the Columbia, stranded ships in port, and closed the ports of Portland, Vancouver, and Kalama for over a month. Several water and sewage treatment facilities were also damaged or destroyed. The estimated damage attributed to the eruption was \$1.1 billion.¹⁹⁷

The May 18, 1980 eruption was preceded by about two months of precursor activity, including dome building, minor earthquakes, and venting of gasses. The lateral blast, debris avalanche, and mudflow associated with the eruptions caused extensive loss of life and widespread destruction of property. The eruption triggered a magnitude 5.1 earthquake about one mile beneath the volcano. In the six-year period after the initial eruption, hundreds of small ash emissions at Mount St. Helens occurred.

The 1980 eruption of Mount St. Helens took the lives of 57 people and nearly 7,000 big game animals. All birds and most small mammals in the area were killed, as were twelve million Chinook and Coho salmon fingerlings that perished when their hatcheries were destroyed.

The May 18, 1980 eruption was followed by five smaller explosive eruptions over a period of five months.¹⁹⁸ A series of sixteen dome-

¹⁹⁴ Tilling, et al. 1990.

<http://www.Vulcan.wr.usgs.gov/Volcanoes/MSH/Hazards>

¹⁹⁵ Hari, Roy. Chief, Marion RFPD No. 1. Personal Interview. November 29, 2004.

¹⁹⁶ “Salem Gets Dusted, But Misses Travel Tie Up.” Statesman Journal. May 26, 1980: Page 1.

¹⁹⁷ USGS. 2010. Economic Impact of the May 18, 1980 Eruption.

http://vulcan.wr.usgs.gov/Volcanoes/MSH/May18/description_economic_impact.html, accessed May 30, 2010.

¹⁹⁸ USGS. Volcanic Hazard Zonation for Mount St. Helens, Washington. 1995. Open-File-Report 95-497.

building eruptions constructed the new, 880 foot high, lava dome in the crater formed by the May 18, 1980 eruption. An eruption occurring in 1480 A.D. was approximately five times larger than the May 18, 1980 event.¹⁹⁹

On the night of March 8, 2005, a plume of ash and steam spewed nearly seven miles high into the air. Glowing tendrils of lava were spotted inside the mountain's crater following the explosion.²⁰⁰ The plume rose nearly twice as high as one produced by the last eruption in October 2004. Ten small earthquakes were measured in the area on Tuesday leading up to the eruption. The largest appeared to be a magnitude 2.5, according to the USGS.²⁰¹

Mount Jefferson

Mount Jefferson (Figure 6) has erupted repeatedly for hundreds of thousands of years, with its last eruptive episode during the last major glaciations, which culminated about 15,000 years ago. Geologic evidence shows that Mount Jefferson is capable of large explosive eruptions. The largest such eruption occurred between 35,000 and 100,000 years ago. If Mount Jefferson erupts again, areas close to the eruptive vent will be severely affected, and even areas tens of kilometers (tens of miles) downstream along river valleys or hundreds of kilometers (hundreds of miles) downwind may be at risk.²⁰²

Figure 6 Mount Jefferson



Source: Schilling, S.P., et al. 2008. "Digital Data for Volcano Hazards in the Mount Jefferson Region, Oregon," <http://pubs.usgs.gov/of/2007/1224/>, accessed February 11, 2010

¹⁹⁹ Community Planning Workshop. 2002.

²⁰⁰ "Scientists Seek Source of Mount St. Helens Blast." CNN.com Web site <<http://www.cnn.com/2005/TECH/science/03/09/saint.helens/>>. Posted March 9, 2005. Accessed March 28, 2005.

²⁰¹ Ibid.

²⁰² <http://vulcan.wr.usgs.gov/Volcanoes/Cascades>. Accessed August 12, 2003 (entire paragraph).

Marion County is vulnerable to an eruption from Mt Jefferson because it lies in the path of a lahar which could impact Detroit Lake and the Detroit and Big Cliff dams. Detroit Lake is a reservoir and popular recreation site impounded behind Detroit Dam, a concrete structure, managed by the US Army Corps of Engineers. Water level in the lake varies greatly during the year, being highest (and close to capacity) from May through August. Lahars entering the lake have the potential to generate waves that could damage shore property and, in the case of large lahars entering the reservoir, waves that could overtop the dam, causing dam failure.²⁰³

Communities in most danger of lahars and other volcanic hazards from an eruptive Mount Jefferson are Idanha and Detroit. Both lie adjacent to the Santiam River and near Detroit Dam.

Three Sisters and Broken Top

The Three Sisters are located about 40 miles southeast of Marion County. Recently, volcanic activity has been found on the South Sister.²⁰⁴ Satellite images have indicated upward movement of land near the volcano. The surface moved toward the satellite (mostly upward) by as much as ten centimeters (about four inches) sometime between August 1996 and October 2000.²⁰⁵ The most likely cause is magma accumulation in the Earth's crust, a process that has been observed with radar interferometry at several other volcanoes worldwide.²⁰⁶ As of 2005 and 2006 USGS found that the rate of ground deformation in the South Sister has slowed.²⁰⁷ There is no immediate danger of a volcanic eruption or other hazardous activity.²⁰⁸ The potential exists, however, that further activity could increase danger.

South Sister, Middle Sister, and Broken Top are major composite volcanoes clustered southeast of Marion County in Deschutes County. These volcanoes have erupted repeatedly over tens of thousands of years and may erupt explosively in the future. In contrast, mafic volcanoes, which range from small cinder cones to large shield volcanoes like the North

²⁰³ http://vulcan.wr.usgs.gov/Volcanoes/Jefferson/Hazards/OFR99-24/OFR99-24_plate1_bw.pdf, Accessed August 20, 2003 (entire paragraph)

²⁰⁴ USGS. Available on the World Wide Web, http://vulcan.wr.usgs.gov/Volcanoes/Sisters/WestUplift/ground_uplift_may2001.html, Accessed August 12, 2003.

²⁰⁵ Ibid.

²⁰⁶ Ibid.

²⁰⁷ USGS. April 11, 2007. Three Sisters Oregon: Information Statement.

http://vulcan.wr.usgs.gov/Volcanoes/Sisters/WestUplift/information_statement_04-11-07.html, accessed May 30, 2010.

²⁰⁸ USGS. Available on the World Wide Web, http://vulcan.wr.usgs.gov/Volcanoes/Sisters/WestUplift/ground_uplift_may2001.html, Accessed August 12, 2003.

Sister, are typically short-lived (weeks to centuries) and erupt less explosively than do composite volcanoes.²⁰⁹

Mount Hood

Mount Hood is located about 60 miles northeast of Marion County. It has been recurrently active over the past 50,000 years. It has had two significant eruptive periods in geologically recent times, one about 1,500 years ago and another about 200 years ago.²¹⁰

While Mount Hood has shown no recent signs of volcanic activity, scientists predict the next eruption will consist of small explosions generating pyroclastic flows, ash clouds, and lahars (mud and debris flows).²¹¹ In the event of an eruption, Marion County would likely be affected by ash fall.

Mount Rainier

Mount Rainier is located approximately 100 miles north of Marion County. Mount Rainier stands at 14,410 feet, and dominates the surrounding landscape as the tallest land feature. The primary hazard posed to Marion County is ash fallout from Mount Rainier.

Mount Rainier is an active volcano that first erupted about half a million years ago. Because of Rainier's great height and northerly location, glaciers have cut deeply into its lavas, making it appear deceptively older than it actually is. Mount Rainier is known to have erupted as recently as in the 1840s, and large eruptions took place as recently as about 1,000 and 2,300 years ago.²¹² An eruption from Mount Rainier would likely impact Marion County only through ash fall.

²⁰⁹ <http://geopubs.wr.usgs.gov/open-file/of99-437/of99-437.pdf>. Accessed August 12, 2003.

²¹⁰ USGS. 2010. Fact Sheet 060-00: Mount Hood – History and Hazards of Oregon's Most Recently Active Volcano. <http://pubs.usgs.gov/fs/2000/fs060-00/>, accessed May 30, 2010.

²¹¹ USGS. 2010. Fact Sheet 060-00: Mount Hood – History and Hazards of Oregon's Most Recently Active Volcano. <http://pubs.usgs.gov/fs/2000/fs060-00/>, accessed May 30, 2010.

²¹² http://vulcan.wr.usgs.gov/Volcanoes/Rainier/summary_mount_rainier.html. Accessed August 20, 2003 (entire paragraph).

Risk Assessment

How are Hazard Areas Identified?

The location of the volcano hazard for Marion County is depicted in the United States Geologic Survey (USGS) Cascades Volcano Observatory (CVO) volcanic hazard zonation reports for Mount Jefferson, produced in 2000. The reports include a description of potential hazards that may occur to immediate communities. These hazards are depicted in Figures 6-8.²¹³ The extent of damage from these hazards depends on the distance from the volcano, vent location, and type of hazardous events that occur during an eruption.

Proximal Hazard Zones 1 and 2 depicted in Figure 6 are areas subject to rapidly moving debris avalanches, pyroclastic flows, and lahars that can reach the hazard boundary in less than 30 minutes, as well as slow-moving lava flows. Areas within proximal hazard zones should be evacuated before an eruption begins because there is little time to get people out of harm's way once an eruption starts. Most pyroclastic flows, lava flows, and debris avalanches will stop within the proximal hazard zone, but lahars can travel much farther.

Distal Hazard Zone 3 depicted in Figure 6 is an area adjacent to rivers that are pathways for lahars. Estimated travel time for lahars to reach these zones is more than 30 minutes, which may allow individuals time to move to higher ground and greater safety if given notice. Lahars could affect transportation corridors by damaging or destroying roads and other infrastructure.

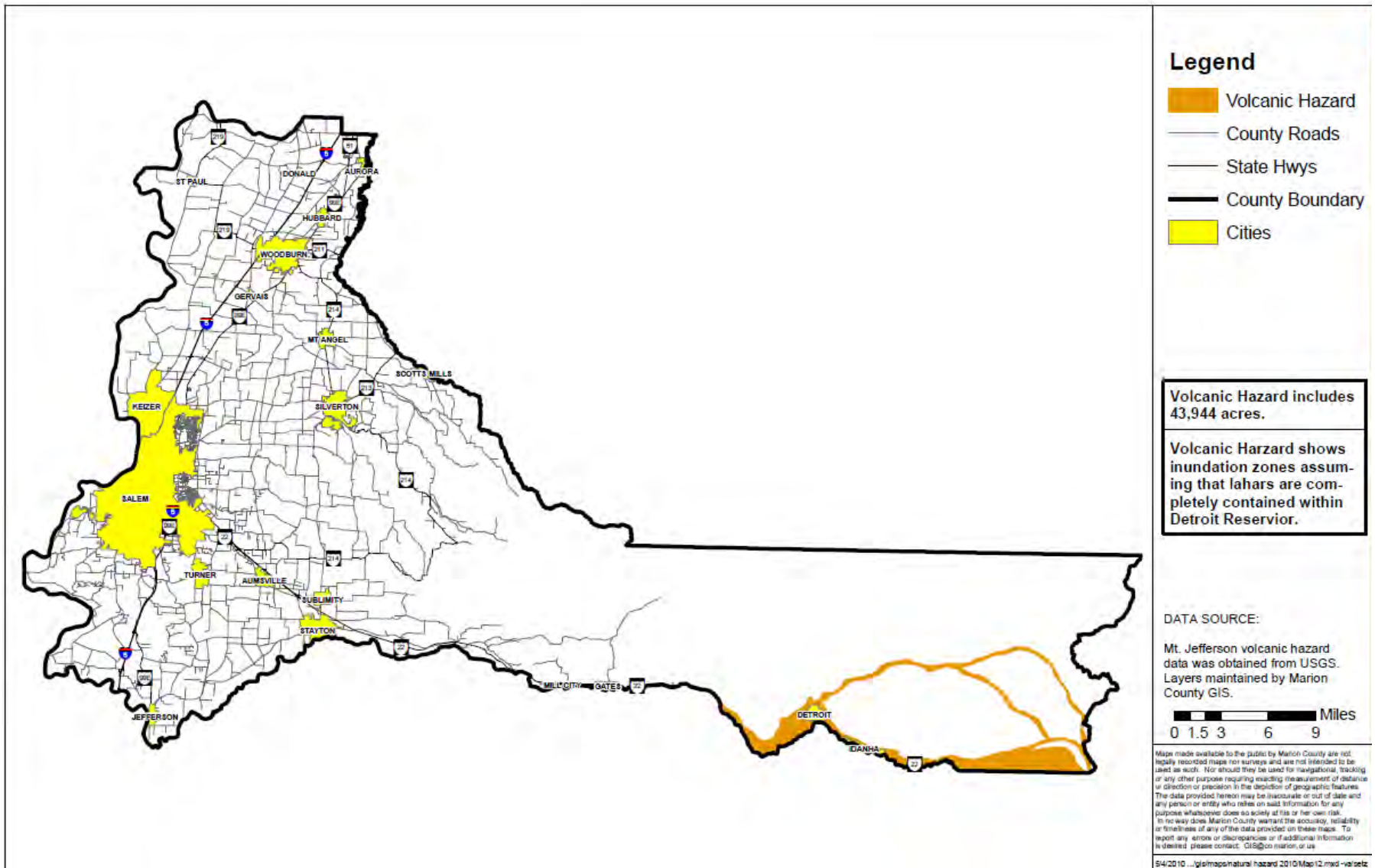
Scientists also use wind direction to predict areas that might be affected by volcanic ash; during an eruption that emits ash, the ash fall deposition is controlled by the prevailing wind direction. The predominant wind pattern over the Cascades originates from the west, and previous eruptions seen in the geologic record have resulted in most ash fall drifting to the east of the volcanoes. Regional tephra fall (shown in Figure 3) shows the annual probability of ten centimeters or more of ash accumulation from Pacific Northwest volcanoes. The same diagram (Figure 3) depicts the potential and geographical extent of volcanic ash fall in excess of ten centimeters from a large eruption of Mt. St. Helens.

²¹³ USGS. 2000. Volcano Hazards in the Mount Jefferson Region, Oregon: Open File Report 99-24. <http://geopubs.wr.usgs.gov/open-file/of99-24/of99-24.pdf>, accessed May 30, 2010.

Insert Figure 6 Volcano Hazards for Mt. Jefferson.

Insert Figure 7.

Figure 8 Composite Volcanic Hazard Map for Marion County



Probability of Future Occurrence

Marion County is closest to the Three Sisters and Mt. Jefferson. Middle and South Sisters are the most active of the group. Because geologic history is fragmentary for these volcanoes, the probability of future explosive eruptions is difficult to estimate. Only two explosive episodes have occurred at the South Sister since the ending of the ice age (about 12,000 years ago). Given the fragmentary record, the annual probability of the South and Middle Sister entering a new period of eruptive activity has been estimated from 1 in several thousand to 1 in 10,000.²¹⁴

Similar difficulties complicate predictions of future eruptions at Mt. Jefferson. There have been four eruptive episodes since the end of the Ice Age (within the last 20,000 years). Such a frequency suggests an annual probability of about 1 in 4,000 to 1 in 3,000.²¹⁵

Table 1 below provides further information about probability of volcanic eruptions in Marion County.

Table 1 Probability of Volcano-Related Hazards

Volcano Related Hazards	Marion County	Remarks
Tephra (volcanic ash) (annual probability of 1cm or more accumulation from eruptions throughout the Cascade Range)	1 in 1,000	USGS Open File Report (OFR 97-513) p.9)
Lahar	Source: Mt. Jefferson, N. & S. Santiam rivers from Mt. Jefferson to Detroit	If the Detroit Lake dam is breached, lahars could reach Mill City, Lyons, and Stayton in Marion County. OFR 99-24 (Maps) Lane County: OFR 99-437 (Map)
Lava flow	Source: Mt. Jefferson Immediate vicinity	Mt. Jefferson: OFR 99-24 (Maps), Three Sisters: OFR 99-437 (Maps)
Debris flow / avalanche	Source: Mt. Jefferson Proximity	Mt. Jefferson: OFR 99-24 (Maps) Three Sisters: OFR 99-437 (Maps)
Pyroclastic flow	Source: Mt. Jefferson Whitewater Cr & S. Fork Santiam	Mt. Jefferson: OFR 99-24 (Maps) Three Sisters: OFR 99-437 (Maps)

Source: USGS, Open File Reports 99-24, 99-437 and 97-513.

Given the low annual probability of a volcanic eruption, the Marion County steering committee rated the probability of volcanic eruption as **low**, meaning that one incident is likely in a 75 to 100 year period. This rating is consistent with the 2006 Marion County Hazard Analysis.

²¹⁴ United States Geologic Survey Open File Report 99-437, p.8.

²¹⁵ United States Geologic Survey Open File Report 99-24, p.11.

Vulnerability Assessment

While a quantitative vulnerability assessment (an assessment that describes number of lives or amount of property exposed to the hazard) has not yet been conducted for Marion County volcanic eruption events, there are many qualitative factors (issues relating to what is in danger within a community) that point to potential vulnerability. The eastern portion of Marion County faces the greatest threat of volcanic eruption from Mount Jefferson. In addition, its proximity to a number of Cascade Range volcanoes places the county at risk from ash fallout originating from such an event.

The Marion County steering committee rated the county's vulnerability to volcanic eruption as **moderate**, meaning 1-10% of the population or regional assets would be affected by a volcano. This is consistent with the 2006 Marion County Hazard Analysis. This number may increase with a higher incidence of ash fallout or if Detroit Dam were to fail. Vulnerabilities are described in detail in the following section community hazard issues.

Risk Analysis

A risk analysis estimating the potential loss of life and property from a volcanic eruption in Marion County has not been completed at this time, but should be completed when data is available (see Multi-Hazard Action # 8).

Community Hazard Issues

What is susceptible to damage during a hazard event?

Mount Jefferson poses the greatest threat of volcanic eruption to Marion County. Located on the eastern edge of the county, Mount Jefferson presents not only a threat of lahars and lava flows, but also a threat of ash fallout. In addition, the county is located within close proximity of other Cascade volcanoes, which present additional threats of ash fallout. The indirect effects of volcanoes within other counties must be considered as well.

Areas of vulnerability in the event of volcanic eruption, for which the greatest threat in Marion County is ash fall, are natural resources, buildings and infrastructure, segments of the population, and the economy.

Natural Resources

Natural resources at risk in Marion County include the rivers and agricultural lands. The Santiam River provides Salem, Stayton, and other communities with drinking water. Ash fall can contaminate the water with particulates making it unsafe to drink. Ash fall can also damage crops which could affect agricultural sales. This could have major implications

for Marion County's economy as the county has the highest agricultural sales of all counties in Oregon.

Building and Infrastructure

Structural damages to buildings and infrastructure can result from the weight of ash, especially if it is wet. Four inches of wet ash may cause buildings to collapse. Ash fall of about 0.4 inch is capable of creating temporary disruptions of transportation operations, sewage disposal, and water treatment systems. Highways and roads could be closed for hours, days, or weeks afterwards. The series of eruptions at Mount St. Helens in 1980 caused Interstate 90 from Seattle to Spokane to close for a week. US Highway 26 in Oregon faced similar problems. The impact of the ash fall caused the Portland International Airport to close for a few days. The airport faced a series of challenges in cleaning up the ash that accumulated on its runways.

The fine-grained, gritty ash can also cause substantial problems for internal-combustion engines and other mechanical and electrical equipment. The ash can contaminate oil systems, clog air filters, and scratch moving surfaces. Fine ash can also cause short circuits in electrical transformers, which in turn cause power blackouts.

On roads and streets, ash fall can create serious traffic problems as well as road damage. Vehicles moving over even a thin coating of ash can cause great clouds of ash to swell. This results in visibility problems for other drivers, calling for speed restrictions, and often forcing road closures. Ash filling roadside ditches and culverts can prevent proper drainage and cause shoulder erosion and road damage. Blocked drainages can also trigger debris flows or lahars if they cause water to pool on or above susceptible slopes. Conventional snow removal methods do not work on dry ash, as they only stir it up and cause it to resettle on the roadway. When ash is pushed to the side of travel lanes, wind and vehicle movement continue to cause it to billow.

During an eruption at Mount Hood, Bonneville Power Administration transmission lines may be severed. A number of high voltage lines are located in the immediate vicinity of Mount Hood. These lines provide a portion of the electrical power to Marion County, the Portland Metropolitan Area, and the rest of the Willamette Valley.

Population

Marion County has several sensitive populations, such as elderly residents and children, who may be affected by air quality during ash fall. Ash fall can severely degrade air quality, triggering health problems. In areas with considerable ash fall, people with breathing problems might need additional services from doctors or emergency rooms. In severe events, an air quality warning, similar to those given on summer problem air quality days, could be issued. This would, for example, warn people with breathing problems not to go outside.

Economy

Volcanic eruptions can disrupt the normal flow of commerce and daily human activity without causing severe physical harm or damage. Ash that is a few inches thick can halt traffic, cause rapid wear of machinery, clog air filters, block drains, creeks, and water intakes, and impact agriculture.²¹⁶ Removal and disposal of large volumes of deposited ash can also have significant impacts on government and business.

The interconnectedness of the region's economy can be disturbed after a volcanic eruption. Roads, railroads, and bridges can be damaged from lahars and mudflows. The Mount St. Helens' May 1980 eruption demonstrated the negative effect on the tourism industry. Conventions, meetings, and social gatherings were canceled or postponed in cities and resorts throughout Washington and Oregon in areas not initially affected by the eruption. The eruption did lead, however, to the creation of a thriving tourist industry for decades following the event.

Transportation of goods may also be halted. Subsequent airport closures can disrupt airline schedules for travelers. In addition, the movement of goods via the Columbia River and other major waterways can also be halted due to debris in the river and tephra in the air. The Mount St. Helens event in May 1980 cost the trade and commerce industry an estimated \$50 million in only two days, as ships were unable to navigate the Columbia.²¹⁷ Clouds of ash often cause electrical storms that start fires and damp ash can short-circuit electrical systems and disrupt radio communication. Volcanic activity can also lead to the closure of nearby recreation areas as a safety precaution long before the activity ever culminates into an eruption.²¹⁸

Existing Hazard Mitigation Activities

Monitoring Volcanic Activity in the Cascade Range²¹⁹

The USGS collaborates with scientists from the Geophysics Program at the University of Washington to monitor seismic activity at both Mount St. Helens and Mount Hood after the May 1980 eruption at Mount St. Helens. When unusual activity is observed, scientists immediately notify government officials and the public. The US Forest Service serves as the primary dissemination agency for emergency information.

As the activity changes, USGS scientists provide updated advisories and meet with local, state, and federal officials to discuss the hazards and

²¹⁶ USGS. March 2001. Volcano Hazards of the Lassen Volcanic National Park Area.

²¹⁷ Clackamas County Courier. October, 1986.

²¹⁸ Cashman, Kathy. University of Oregon Department of Volcanology. Personal Interview. March 14, 2001.

²¹⁹ See USGS's website for updates on volcano hazard levels in the Cascade Range listed here. http://volcano.wr.usgs.gov/cvo/current_updates.php

appropriate levels of emergency response. The experience since 1980 at Mount St. Helens and elsewhere indicates that monitoring is sufficient for scientists to detect the ascent of fresh magma that must take place before another large eruption. This information will enhance warnings and facilitate updated assessments of the hazard.

In addition, the USGS and the National Weather Service monitor lahar and flood hazards at Mount St. Helens. The latter agency has responsibility for providing warnings of floods, including lahars. These monitoring activities not only help nearby communities, but can also provide significant benefit to the Pacific Northwest, including Marion County.

Volcanic Event Notification Emergency Coordination

An emergency coordination center (ECC) was established at the US Forest Service (USFS) facility in Vancouver, Washington after the 1980 eruption of Mount St. Helens. A communications network and telephone call-down procedure was developed to facilitate rapid dissemination of information about the activity of the volcano.

Information is also disseminated through public meetings, press conferences, and briefings with governmental agencies and private businesses. Currently, the system has the capability of issuing written predictions weeks in advance of most eruptions. This eliminates the need for 24-hour duty for USFS, ECC and CVO staff except when eruptions are imminent. It can enter all predictions and updates into a computer "news" system for easy review by those on the call-down list; update volcanic activity reports when the volcano is quiet; and develop a seismic alarm to alert scientists to small events that occur without precursors.

Hazard Mitigation Action Items

The following actions have been identified by the Marion County steering committee, and are recommended for mitigating the potential effects of volcanic eruptions in Marion County. Please see full action item worksheets in Appendix A.

Volcano Action Items

VE1: Collaborate with county environmental health for immediate warnings to communities about degraded air quality following volcanic eruptions, particularly in areas with high concentration of vulnerable groups (e.g. retirement facilities and schools).

VE2: Collaborate with USGS-CVO and related agencies to develop ash fall models that are specific to Marion County.